Summer 2016

QUEST

RESEARCH NEWS FROM PPPL

HERE COMES THE SUN

PPPL PRINCETON PLASMA PHYSICS LABORATORY

U.S. DEPARTMENT OF ENERGY

PRINCETON UNIVERSITY

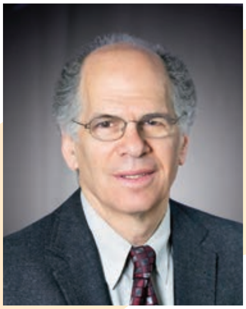
Summer 2016

David McComas
Princeton University
Vice President for PPPL

FROM THE NEW UNIVERSITY VICE PRESIDENT FOR PPPL

I am honored to succeed A.J. Stewart Smith as Princeton University's vice president for PPPL, and am very excited to help oversee the nation's leading center for the exploration of plasma science and magnetic fusion energy. My own background is in space plasma physics and in the engineering of space instrumentation. I have worked in these areas for the past 35 years, both at Southwest Research Institute in San Antonio, Texas, a nonprofit organization that specializes in the creation and transfer of technology in engineering and the physical sciences, and at Los Alamos National Laboratory, where I founded its Center for Space Science and Exploration.

I serve as the University's primary contact with the U.S. Department of Energy on matters related to PPPL. The Laboratory has entered a new and exciting era with the completion of the National Spherical Torus Experiment-Upgrade and continuing advances in plasma science. I really look forward to overseeing the Laboratory's management and operation at this exciting time and in working to grow the PPPL program and to help develop the world-wide vision that will make fusion energy a reality in our lifetimes!



Stewart Prager
PPPL Director

FROM THE DIRECTOR OF PPPL

It is my pleasure to welcome readers to the fourth annual edition of Quest, the Laboratory's research magazine. Research has begun full bore on the National Spherical Torus Experiment-Upgrade (NSTX-U), our flagship fusion facility, whose construction was completed in 2015 after nearly four years of building and a cost of $94 million. The upgrade has doubled the machine's heating power and magnetic field strength, lengthened its operation from one second to five, and made it the most powerful spherical tokamak in the world. These improvements will enable researchers to address some of fusion's most outstanding scientific puzzles and will demonstrate whether the compact design of the spherical tokamak — which is shaped like a cored apple rather than the doughnut-like shape of conventional tokamaks — can serve as a candidate for a next major step in the U.S. fusion program.

We are rapidly advancing in a number of other areas. Research is beginning in our new, state-of-the-art laboratory that investigates the use of plasma to produce nanoparticles, material measured in billionths of a meter that has broad consumer and industrial applications. Work is scheduled for completion this year on FLARE, a more powerful version of our present facility for studying a crucial astrophysical phenomenon called magnetic reconnection under laboratory conditions. And we are installing a powerful neutral beam to fuel the core of the plasma in the Lithium Tokamak Experiment (LTX), which studies the use of liquid lithium to protect the walls of fusion facilities and has demonstrated that such novel materials improve containment of the high-temperature fusion plasma.

Our research and contributions extend to facilities around the world. We lead U.S. participation in Germany's Wendelstein 7-X (W7-X) stellarator that began operating last December, and have provided it with diagnostic and magnetic components. For ITER, the international experiment under construction in France, we manage U.S. contributions to diagnostics and are responsible for delivering 75 percent of the steady state electrical network that will run everything in the plant except for the huge tokamak. The past year has seen our researchers contribute to breakthroughs on the DIII-D tokamak that General Atomics operates for the U.S. Department of Energy in San Diego, and participate in research on the supercomputing EAST and KSTAR tokamaks in China and South Korea, respectively.

These are some of the activities in fusion and plasma physics that our scientists and engineers are deeply engaged in. Looking ahead, we have now begun work on a 10-year plan to modernize our campus to fully support the exciting research that we currently conduct and plan for the coming years — research whose challenges, when met, will help to change the world.

On the cover: The National Spherical Torus Experiment-Upgrade produced this plasma, here superimposed on a photo of the interior of the tokamak, in research designed to lead to the creation of a star on Earth.

CONTENTS

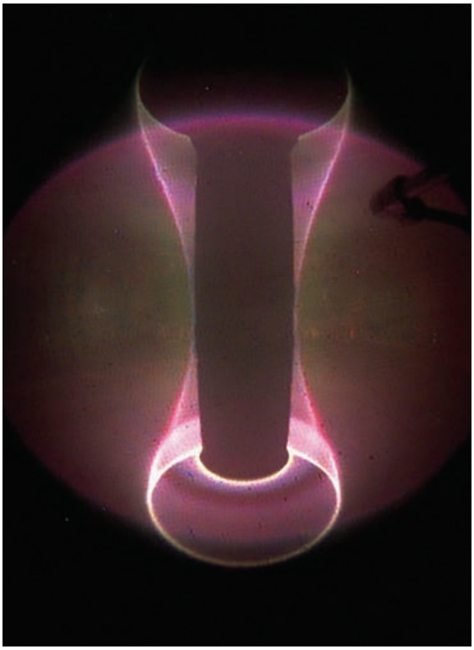
RESEARCH ROARS AHEAD ON THE WORLD'S MOST POWERFUL SPHERICAL TOKAMAK

ALL EYES ARE ON SCREENS AS THE SECONDS COUNT DOWN. Physicists are busily exploring the advanced capabilities of the National Spherical Torus Experiment-Upgrade (NSTX-U), now the most powerful fusion facility of its kind in the world. As the control room clock reaches "zero" measurements flash on an overhead screen and a fast camera records the birth of a plasma.

Such experiments are repeated some 20 times a day as scientists from PPPL and around the world make use of the NSTX-U's nearly three-year upgrade, which was completed last year. The $94 million overhaul has doubled the facility's magnetic field strength and heating power and improved its ability to create dense and energetic plasmas — the superhot, charged gas composed of electrons and atomic nuclei that fuel fusion reactions.

Research on the NSTX-U, the newest addition to the U.S. fusion program in the 21st century, exploits its cored apple-like design. This design produces high-pressure plasmas with lower magnetic fields than do doughnut-shaped conventional tokamaks that are much more common. The distinction makes spherical tokamaks a cost-effective alternative since high-pressure plasmas are essential for fusion reactions and magnetic fields are expensive to produce.

The spherical design could also serve as a model for the next major step in the U.S. program to develop fusion as a clean, safe and virtually limitless source of energy for generating electricity. With that goal in mind, researchers will be probing a range of key issues.



Outline of hourglass-shaped plasma produced in the NSTX-U superimposed on photo of interior of the tokamak.

"One of the major goals for NSTX-U this year has been to produce plasmas with higher current, longer pulse length and more stored energy than before the upgrade," said Masa Ono, project director for the NSTX-U. Researchers have been investigating whether the plasma grows hotter — an essential ingredient for fusion reactions — or if increased turbulence causes the heat to leak out. "We hope to double the temperature," Ono says.

Future plans call for exploring ways to create and sustain the crucial current in plasma without using the transformer that sits in the center of the NSTX-U and cannot run for long periods of time. Experiments will use the second neutral beam injector, a heating device installed in the upgrade, to drive more of the current in plasma that keeps the hot gas from flying apart. "Sustaining the plasma current for a few seconds without using the transformer would be a very important step," said Jon Menard, program director for the NSTX-U, since the duration could then be scaled up.

Still other experiments could be critical for ITER, the multinational tokamak under construction in France to demonstrate the feasibility of fusion power. ITER's scientific goal is to heat the plasma primarily from energetic nuclei generated from fusion reactions. But these nuclei could also drive turbulence that causes them to be lost to the reactor walls. NSTX-U is uniquely capable of addressing this issue by using its expanded ability to vary the velocity of the nuclei to develop advanced models and controls for predicting and mitigating such losses. "ITER is a conventional tokamak," said Menard. "But our spherical tokamak can be used to prototype important aspects of ITER fusion physics and provide vital predictive capability to ITER."

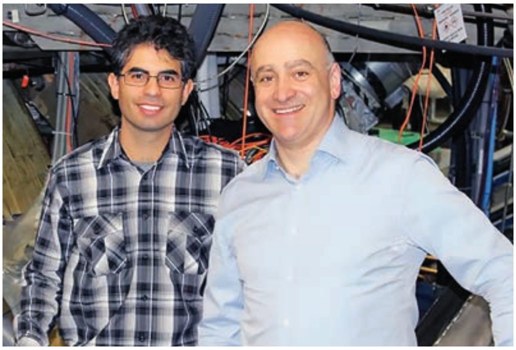
BREAKTHROUGH IN UNDERSTANDING HOW TO CONTROL INTENSE HEAT BURSTS

SCIENTISTS FROM GENERAL ATOMICS and PPPL have taken a key step in predicting how to control potentially damaging heat bursts inside a fusion reactor. In experiments on the DIII-D National Fusion Facility that General Atomics operates for the DOE in San Diego, the physicists built upon previous DIII-D research showing that these intense heat bursts — called edge localized modes (ELMS) — could be suppressed with tiny magnetic fields. But how these fields worked had been unclear.

Two complementary studies revealed the new findings. The first, led by General Atomics researcher Carlos Paz-Soldan, found that the fields can create two kinds of response, one of which allows heat to leak from the edge of the plasma at just the right rate to avert the heat bursts. The second result, led by PPPL scientist Raffi Nazikian, who heads the PPPL team at DIII-D, identified the changes in the plasma that lead to suppression of the bursts.

Two complementary studies revealed the new findings.

Both studies involved a multi-institutional team of researchers who for years have been working toward an understanding of these processes. The researchers included physicists from General Atomics, PPPL, Oak Ridge National Laboratory, Columbia University, Australian National University, the University of California-San Diego, the University of Wisconsin-Madison, and several others.



Carlos Paz-Soldan, left, and Raffi Nazikian at the DIII-D tokamak.

Digital Protection for the NSTX-U

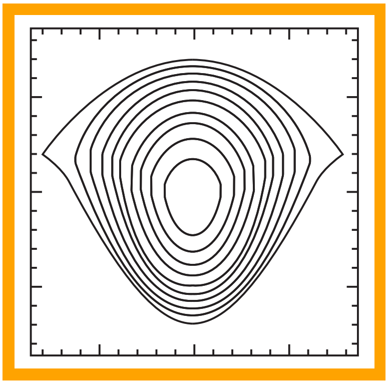
As the most powerful spherical tokamak in the world, the National Spherical Torus Experiment-Upgrade (NSTX-U) produces magnetic forces that are far greater than what its predecessor could generate. Moreover, the power supply that drives current in the fusion facility's electromagnetic coils can potentially produce even higher forces unless properly constrained. PPPL engineers have therefore produced a state-of-the-art Digital Coil Protection System (DCPS) that replaces the analog system on the old NSTX that was too limited for the new operating levels.

The digital system, the first of its kind for a fusion facility, computes forces and stresses that come from the current that flows in all the coils and in the plasma that fuels fusion reactions. The DCPS checks critical variables during each NSTX-U shot at a rate of 1,200 times every 200 microseconds and forces a shutdown if pre-set limits are approached. The system has caught things it was supposed to catch and plays a critical role in protecting the upgraded facility.

EXPLAINING A MYSTERIOUS BARRIER TO FUSION KNOWN AS THE "DENSITY LIMIT"

FOR MORE THAN 50 YEARS PHYSICISTS have puzzled over a daunting mystery: Why do tokamak plasmas spiral apart when reaching a certain density and halt fusion reactions? The limit serves as a barrier that prevents tokamaks from operating at peak efficiency, and finding the answer could speed the development of fusion as a safe, clean and abundant source energy.

David Gates



Magnetic island geometry showing the asymmetry effect that is crucial in determining the mechanism for the density limit.

Physicist David Gates and fellow PPPL researchers have now produced a detailed model of the puzzling source of the density limit. It identifies the source as the runaway growth of bubble-like islands that form within, and cool down, the magnetically confined plasma that fuels fusion reactions.

The research locates the mechanism in the cooling of the islands by impurities that stray plasma particles kick up from the walls of the tokamak. Countering this cooling is heating that researchers pump into the plasma. But the scientists found that even a tiny bit of net cooling in the interior of the islands can cause them to become asymmetric and grow exponentially, leading to disruption of the crucial current that runs through the plasma and completes the magnetic field that holds the hot gas together.

Physicist David Gates and fellow PPPL researchers have now produced a detailed model of the puzzling source of the density limit.

If confirmed by experiment, the findings could lead to steps to overcome the barrier, which also is known as the "Greenwald limit" after MIT physicist Martin Greenwald, who derived an empirical rule for it.

GRADUATE STUDENTS FROM TWO BRITISH UNIVERSITIES INSTALL A CRITICAL NEW DIAGNOSTIC ON NSTX-U

A SYSTEM OF ANTENNAS SIMILAR to those that astrophysicists use to study radio emissions from stars and galaxies will help shed light on fusion experiments at PPPL. Called Synthetic Aperture Microwave Imaging (SAMI), the system aims to provide highly precise time and spatial resolution measurements of the density of current at the edge of fusion plasmas in the NSTX-U tokamak.

High-resolution measurements of the edge current density are key to understanding instabilities called Edge Localized Modes (ELMs) that can foil experiments during the high-level performance of fusion plasmas. Large ELMs can eject significant amounts of energy that can damage the interior walls of tokamaks and generate impurities that can significantly degrade the reactions.

The two graduate students, David Thomas of the University of York and Jakob Brunner of Durham University brought the SAMI system, which consists of an array of eight antennas, to PPPL from Britain last November. It was originally installed on the Mega Amp Spherical Tokamak (MAST) at the United Kingdom's Culham Centre for Fusion Energy. MAST is an NSTX-U-like system that is currently shut down for a major upgrade. Now modified to meet NSTX-U requirements, the SAMI plasma diagnostic will start acquiring data during the 2016 NSTX-U research campaign.

Above, from left: Jakob Brunner and David Thomas, with advisor Prof. Roddy Vann of the University of York on the screen in the center.

SCIENTISTS PROPOSE AN EXPLANATION FOR PUZZLING ELECTRON HEAT LOSS IN FUSION PLASMAS

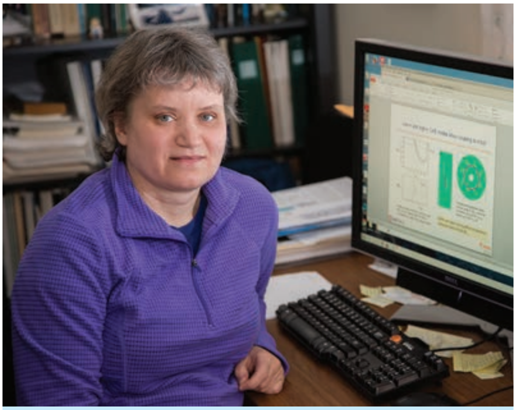
CREATING CONTROLLED FUSION energy entails many challenges, but one of the most basic is heating hot plasma — gas composed of electrons and charged atomic nuclei — to extremely high temperatures and maintaining those temperatures. PPPL physicist Elena Belova and a team of collaborators have proposed an explanation for why the plasma within fusion facilities called tokamaks sometimes fails to reach the required temperature, even as researchers pump beams of fast-moving neutral atoms into the plasma to make it hotter.

"In simulations, you can look everywhere in a plasma"

This question is one of the largest remaining mysteries in plasma physics. Belova hit upon a possible answer while performing 3D simulations of plasmas on the National Spherical Torus Experiment before its recent upgrade. "In simulations you can look everywhere in a plasma," Belova said. "In the experiments, on the other hand, you are very limited in what and where you can measure inside the hot plasma."

Her team produced computer simulations that showed that two kinds of waves in fusion plasmas appear to form a chain that causes the electron heat to dissipate. When physicists pump beams of deuterium, a form of hydrogen, to heat the plasma, the beams excite compressional Alfvén (CAE) waves in the plasma's core. These waves then resonate with kinetic Alfvén (KAW) waves that occur primarily at the plasma's edge, transferring energy from the core to the edge of the plasma, where the electron heat is lost.

Her finding of a chain that causes electron heat to dissipate could lead to improved control of temperature in future fusion devices, including ITER, the international fusion facility under construction in France to demonstrate the feasibility of fusion power.



Elena Belova

MODELING WAYS TO START AND SUSTAIN PLASMA CURRENT WITHOUT USING A SOLENOID

TOKAMAKS IN USE TODAY CREATE and maintain the plasma that fuels fusion reactions with solenoids — large magnetic coils that wind down the center of the vessels and inject the current that starts the plasma and completes the magnetic field that holds the gas in place. But future tokamaks will need to do without solenoids, which run only in short pulses rather than for weeks or months at a time as commercial plants will have to do.

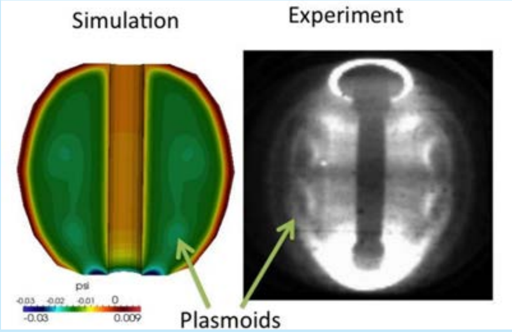
At PPPL, researchers are working on several projects to eliminate solenoids. In one study led by physicist Fatima Ebrahimi, researchers have simulated the formation of structures called "plasmoids," which are like magnetic bubbles that induce the plasma current. The team modeled the formation during a process called Coaxial Helicity Injection (CHI), which injects open magnetic field lines into a tokamak. As researchers drive current along these field lines they snap closed to form many small plasmoids that merge into a single big one that fills the vessel and induces the current.

Sustaining the current initiated by CHI requires additional techniques. In another seminal study led by physicist Francesca Poli, researchers have used radio waves to simulate the maintenance of the current. They found that combining two types of radio waves — electron cyclotron waves that resonate with electrons that circle the magnetic field lines and what are called High Harmonic Fast Waves — can enable a plasma current to be sustained and grow.

Taken together, these results suggest that it will be possible to start and sustain the vital plasma current without solenoids in future tokamaks.

Fatima Ebrahimi

Francesca Poli



Simulation of plasmoid formation during CHI in National Spherical Torus Experiment (NSTX) prior to its upgrade, and fast-camera image of plasma in NSTX showing cross-section of two discreet plasmoid-like bubble structures.


Stephen Jardin, right, with summer intern.

USING POWERFUL COMPUTERS, PHYSICISTS UNCOVER MECHANISM THAT STABILIZES PLASMA WITHIN TOKAMAKS

FOR FUSION REACTORS TO BE MOST SUCCESSFUL, THE ELECTRIC CURRENT that flows through fusion plasma must not periodically peak and crash in mini-disruptions known as "sawtooth cycles." Now a team of physicists led by PPPL scientist Stephen Jardin has discovered a mechanism that prevents such cycles.

Using the most powerful super-computers, the team found that under certain conditions a helix-shaped whirlpool of plasma forms around the center of the tokamak. This whirlpool acts like a dynamo, a moving fluid that creates electric and magnetic fields and prevents the current flowing through plasma from peaking and crashing.

The researchers found two conditions under which the plasma behaves like a dynamo. First, the magnetic lines that circle the plasma must rotate exactly once, both the long way and the short way around the doughnut-shaped configuration. Second, the pressure in the center of the plasma must be significantly greater than at the edge.

Once a range of conditions like pressure and current are set, the dynamo phenomenon occurs all by itself. "We don't have to do anything else from the outside," Jardin noted. "It's something like when you drain your bathtub and a whirlpool forms over the drain by itself."

Physicists hope to learn to create these necessary conditions on demand in ITER, the huge multinational fusion facility being constructed in France to demonstrate the practicality of fusion power.

IMPROVING THE GLOBAL STANDARD FOR MODELING FUSION PLASMAS

THE GOLD STANDARD FOR MODELING the behavior of fusion plasmas may have just gotten better. Physicist Mario Podestà has updated the worldwide computer program known as TRANSP to better simulate the interaction between energetic particles and instabilities – disturbances in plasma that can halt fusion reactions. The program's updates could lead to improved capability for predicting the effects of some instabilities in future facilities such as ITER, the international experiment under construction in France to demonstrate the feasibility of fusion power.

Podestà and co-authors noticed that TRANSP, which PPPL developed and has regularly updated, treated all fast-moving particles within the plasma the same way, even though they produced instabilities in different ways through so-called "resonant processes." The authors then figured out how to condense information from codes that do model the interactions accurately so that TRANSP could incorporate that information into its simulations.

Podestà teamed up with Gorelenkova to update NUBEAM

Podestà then teamed up with TRANSP developer Marina Gorelenkova at PPPL to update a TRANSP module called NUBEAM to enable it to make sense of this condensed data to improve simulations of different types of instabilities in plasma.

Mario Podestà

Marina Gorelenkova

DISCOVERING A PREVIOUSLY UNKNOWN MECHANISM THAT HALTS SOLAR ERUPTIONS BEFORE THEY BLAST INTO SPACE

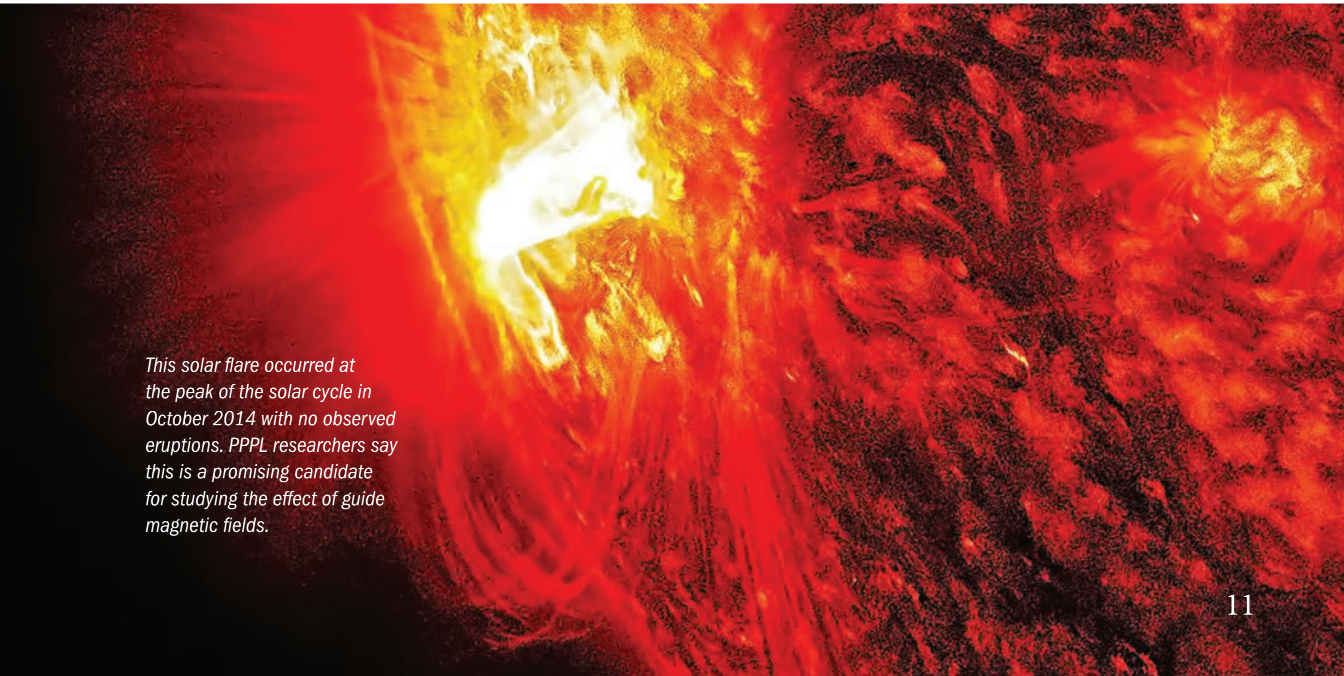
AMONG THE MOST FEARED EVENTS in space physics are solar eruptions, massive explosions that hurl millions of tons of plasma gas and radiation into space. These outbursts can be deadly: if the first moon-landing mission had encountered one, the intense radiation could have been fatal to the astronauts. And when eruptions reach the magnetic field that surrounds the Earth, the contact can create geomagnetic storms that disrupt cell phone service, damage satellites and knock out power grids.

NASA is eager to know when an eruption is coming and when what looks like the start of an outburst is just a false alarm.

Researchers at PPPL led by associate research physicist Clayton Myers have identified a mechanism that may halt the eruptions before they leave the sun. Such eruptions, called "coronal mass ejections," stem from a sudden release of magnetic energy that is stored in the sun's corona, the outermost layer of the star. This energy is often found in what are called "magnetic flux ropes," massive arched structures that can twist and turn like earthly twine.

The researchers found in laboratory experiments that eruptions fail when the guide magnetic field — a force that runs along the flux rope — is strong enough to keep the rope from twisting and destabilizing. Under these conditions, the guide field interacts with electric currents in the flux rope to produce a dynamic force that halts the eruptions. PPPL has discovered the importance of this force, called the "toroidal field tension force," which is missing from existing models of solar eruptions.

Solar physicists should thus be on the lookout for substantial guide fields, which can be found in relatively simple reconstructions of the sun's potential magnetic field.



This solar flare occurred at the peak of the solar cycle in October 2014 with no observed eruptions. PPPL researchers say this is a promising candidate for studying the effect of guide magnetic fields.

PPPL PHYSICISTS DEVELOP NEW PLASMA-BASED METHOD TO TREAT RADIOACTIVE WASTE

PPPL PHYSICISTS ARE DEVELOPING a new way to process nuclear waste that uses a plasma-based centrifuge. Known as plasma mass filtering, the new mass-separation techniques supplement chemical techniques. This combined approach could reduce the cost of nuclear waste disposal and cut down the amount of byproducts produced during the process.

The immediate motivation for safe disposal is the radioactive waste stored currently at the Hanford Site, a facility in Washington State that produced plutonium for nuclear weapons during the Cold War. The volume of this waste originally totaled 54 million gallons and was stored in 177 underground tanks. Overall, the Department of Energy estimates the cleanup cost for all nuclear waste sites to be over 280 billion dollars.

Currently, the most radioactive fraction of the waste is separated from the bulk and encased in glass canisters in a process known as “vitrification” and stored for thousands of years. This process and storage are expensive so reducing the amount of waste that needs to be stored is important.

The plasma-based mass separation techniques advanced at PPPL by physicists Renaud Gueroult and Nat Fisch could reduce the volume of waste that needs to be vitrified.

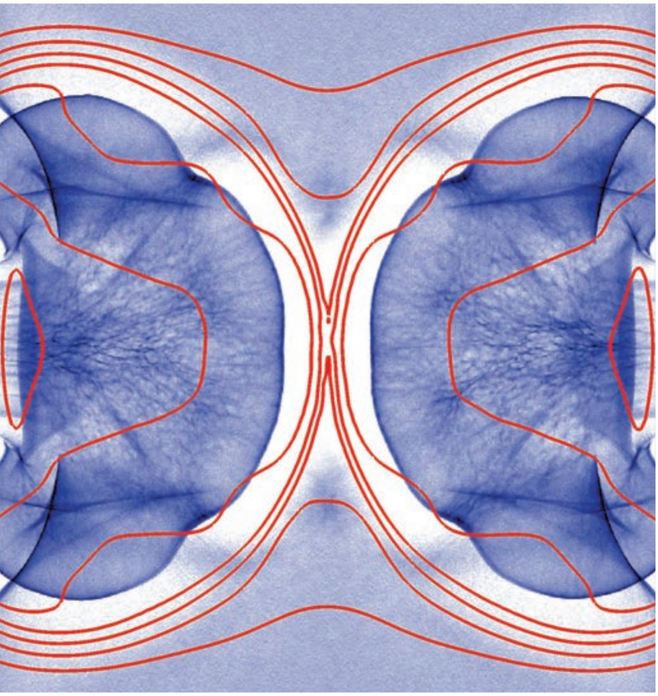
Securing a shipment of mixed, low-level waste from Hanford for treatment and disposal.

The plasma-based mass separation techniques advanced at PPPL by physicists Renaud Gueroult and Nat Fisch could reduce the volume of waste that needs to be vitrified. First, researchers ionize the hazardous material so the individual elements can be influenced by electric and magnetic fields. The ionized material is then injected into a rotating plasma filter which separates the lighter elements from the heavier ones by using centrifugal and magnetic forces.

The lighter elements are typically less radioactive than the heavier ones and often do not need to be vitrified. Nuclear technicians would therefore need fewer glass canisters overall, since only the heavier waste routinely requires vitrification and the less radioactive material can be immobilized in less costly packaging.

PPPL TEAM WINS 80 MILLION PROCESSOR HOURS ON NATION'S FASTEST SUPERCOMPUTER

THE U.S DEPARTMENT OF ENERGY has awarded a total of 80 million processor hours on the fastest supercomputer in the nation to an astrophysical project based at PPPL. The grants will enable researchers led by Amitava Bhattacharjee, head of the Theory Department at PPPL, and physicist Will Fox to study the dynamics of magnetic fields in the high-energy density plasmas that lasers create. Such plasmas can closely approximate those that occur in astrophysical objects.



Model of colliding magnetic fields before magnetic reconnection.

The awards consist of 35 million hours from the INCITE (Innovative and Novel Impact on Computational Theory and Experiment) program, and 45 million hours from the Advanced Scientific Computing Research Leadership Computing Challenge. Both will be carried out on the Titan Cray XK7 supercomputer at Oak Ridge National Laboratory.

The combined research will shed light on large-scale magnetic behavior in space and will help design three days of experiments in 2016 and 2017 on the world's most powerful high-intensity lasers at the National Ignition Facility (NIF) at the DOE's Lawrence Livermore National Laboratory. "This will enable us to do experiments in a regime not yet accessible with any other laboratory plasma device," Bhattacharjee said.

Joining Bhattacharjee and Fox on the INCITE award will be astrophysicists Kai Germaschewksi of the University of New Hampshire and Yi-Min Huang of PPPL. The same team is conducting the 45 million-hour research with the addition of Jonathan Ng of Princeton University. Researchers on the NIF experiments, for which Fox is principal investigator, will include Bhattacharjee and collaborators from PPPL, Princeton, the universities of Rochester, Michigan and Colorado-Boulder, and NIF and the Lawrence Livermore National Laboratory.

Delivery of the first PPPL purchased transformer for the Steady State Electrical Network at ITER.

LAB TEAMS PROVIDE KEY CONTRIBUTIONS TO ITER, THE WORLD'S LARGEST FUSION EXPERIMENT

ENGINEERS AT PPPL HEAD TEAMS responsible for two major hardware contributions that the United States is supplying to ITER, the international experiment under construction in France to demonstrate the power plant-scale production of fusion energy.

In one project, the Laboratory is purchasing some $40 million of electrical equipment that will comprise ITER's Steady State Electric Network (SSEN), which is similar — but larger — than systems used in conventional power plants. This substation and distribution system will power all the complex plant's electrical loads except for the pulsed loads that will power the heating, current and magnetic fields inside the giant tokamak itself.

The PPPL team led by engineer Charles Neumeyer has so far signed 13 of 16 SSEN contracts and completed delivery of 11 electrical systems, including a group of four 87-ton transformers. In so doing, PPPL accomplished the first-ever delivery of plant components to the ITER site and paved the way for all future shipments of ITER components.

Another PPPL team headed by engineer Russ Feder is leading the development of seven diagnostic instruments to be housed in four port plugs that face the plasma. The sensitive tools, valued at some $200 million, must be arranged inside shield modules to withstand the intense heat and high neutron radiation from fusion experiments, and extreme electromagnetic loads if the plasma disrupts.

The Laboratory is partnering with universities and industry on the development of these systems and has placed contracts for five of them, with PPPL and Oak Ridge National Laboratory each designing one of the remaining two systems. The ITER Organization (IO) will review all preliminary designs in 2017.

Feder's team is also developing solutions for integrating the diagnostics inside the shield modules. Engineer Yuhu Zhai oversees this work, with engineers Alan Basile and Ankita Jariwala addressing the individual shield modules.

Also being designed are diagnostic first walls that will cap and remove heat from the shield modules. Leading this work under a "task agreement" — a separate ITER contract — is engineer Doug Loesser. His team won the contract after the IO commended it in 2014 for its preliminary work on the project.

ELIOT FEIBUSH LEADS NEW CONSORTIUM ON VISUALIZATION


Eliot Feibush

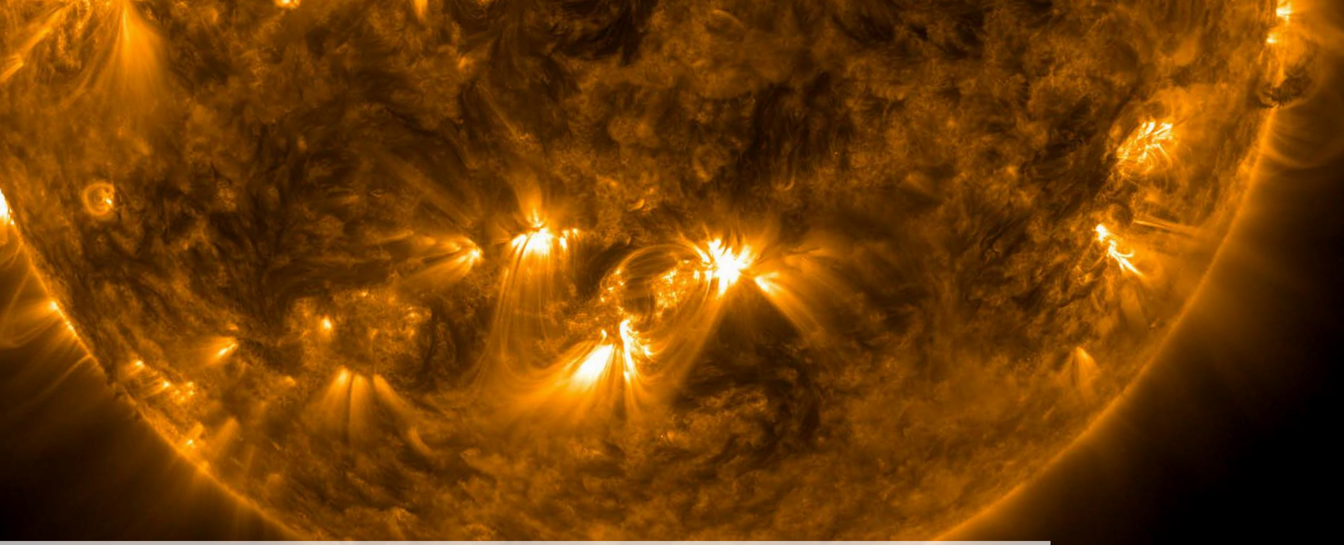
IF A PICTURE IS WORTH A THOUSAND words, a computer graphic is worth millions. With that thought in mind, PPPL has named Computational Scientist Eliot Feibush to lead a new University consortium that will share efforts to turn mountains of scientific data into eye-friendly computer visualizations. Joining PPPL in this venture are the Princeton Institute for Computational Science & Engineering (PICSciE) and the Geophysical Fluid Dynamics Laboratory (GFDL), institutions whose research ranges from exploring supernovae and the interior of the Earth to predicting climate variability and change.

"People are modeling ever-larger and more complex processes," said Feibush, who heads the development of web-based software for imaging data from fusion experiments at PPPL. "Visualization is a way to see all the data in a human way and produce new scientific insights."

PPPL has named Computational Scientist Eliot Feibush to lead a new University consortium that will share efforts to turn mountains of scientific data into eye-friendly computer visualizations

As technical leader of the new collaboration, Feibush will develop new software tools for importing data into visualizations and will tutor researchers from grad students to professors on using the tools. Programs will be stored on a remote server from which they can be readily launched from desktop or laptop computers.

Among benefits of the new collaboration will be tutelage by Feibush in programs such as Visualization Toolkit software, an advanced method for visualizing data. Trained use of the program can enable researchers with little prior experience with the software to distill massive amounts of data into clear and concise imagery.



CORRELATING AUTOIMMUNE DISEASES WITH SOLAR CYCLES

A coronal mass ejection hurling plasma from the sun.

WHAT BEGAN AS A CHAT BETWEEN husband and wife has evolved into an intriguing scientific discovery. The results show a “highly significant” correlation between periodic solar storms and incidences of rheumatoid arthritis (RA) and giant cell arteritis (GCA), two potentially debilitating autoimmune diseases.

RA and GCA are autoimmune conditions in which the body mistakenly attacks its own organs and tissues. RA inflames and swells joints and can cause crippling damage if left untreated. In GCA, the autoimmune disease results in inflammation of the wall of arteries, leading to headaches, jaw pain, vision problems and even blindness in severe cases.

Inspiring this study were conversations between Simon Wing, a Johns Hopkins University physicist and first author of the paper, and his wife, Lisa Rider, deputy unit chief of the Environmental Autoimmunity Group at the National Institute of Environmental Health Sciences in the National Institutes of Health. Rider spotted data from the Mayo Clinic in Rochester, Minnesota, showing that cases of RA and GCA in Olmsted County, Minnesota, followed close to 10-year cycles — roughly the same as the cycle of solar activity.

Wing teamed with PPPL physicist Jay Johnson, a long-time collaborator, to investigate further. When the physicists tracked the incidence of RA and GCA cases compiled by Mayo Clinic researchers, the results suggested more than a coincidental connection.

Rider spotted data showing that cases of RA and GCA followed close to 10-year cycles — roughly the same as the cycle of solar activity.

Confirming a causal link between outbreaks of the diseases and geomagnetic activity would be an important step towards developing strategies for mitigating the impact of the activity on susceptible individuals. For now, say the authors, their findings warrant further investigation covering longer time periods, additional locations and other autoimmune diseases.

PPPL CELEBRATES START-UP AND FIRST HYDROGEN PLASMA OF WENDELSTEIN 7-X STELLARATOR

SCIENTISTS AT PPPL JOINED THE celebration for the first plasma of the Wendelstein 7-X (W7-X) stellarator, the largest and most advanced fusion experiment of its kind in the world, at the Max Planck Institute in Greifswald, Germany on Dec. 10, 2015. At the site for the event were physicists Dave Gates, Sam Lazerson and Novimir Pablant.

Laboratory members were also on hand on February 3, 2016, when German Chancellor Angela Merkel pushed a button to produce a hydrogen plasma that launched the facility's research program. Present were A.J. Stewart Smith, then-Princeton University vice-president for PPPL, who greeted Merkel on behalf of the U.S. delegation, and physicist Hutch Neilson, head of advanced projects at PPPL, together with Lazerson and Pablant.

PPPL leads the U.S. collaboration on experiments on the W7-X and designed and delivered five barn-door size magnetic coils that will help shape the plasma during the experiments. Stellarators confine fusion plasmas in twisty magnetic fields, compared with the symmetrical fields that tokamaks produce.

PPPL also designed and installed an X-ray diagnostic system that will collect vital data from the plasma in the machine. "W7-X is a fantastic experiment," said PPPL Director Stewart Prager. "It's going to be critical to the future of stellarator research in the world."

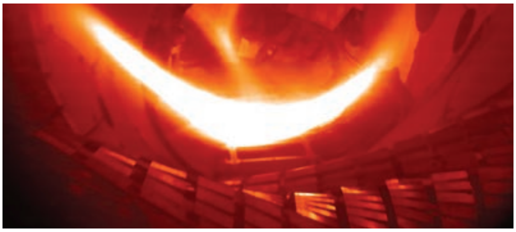


Image of the first hydrogen plasma inside the Wendelstein 7-X.

A SPACE-AGE EXPERIMENT FOR THE INTERNATIONAL SPACE STATION

LENORE RASMUSSEN, A SYNTHETIC polymer chemist, has worked with PPPL scientists to create material that can serve as synthetic muscle for use in robotics and prosthetic limbs. PPPL helped develop the ability of the material, an electroactive polymer, to adhere to metal. And Rasmussen, who owns RAS Labs in Quincy, Massachusetts, found no change in the material's strength, electroactivity, or durability when exposed to radiation in tests at the Lab.

NASA last year rocketed the material to the International Space Station aboard SpaceX Falcon 9 to test its resistance to radiation in space. The material lifted off in April 2015 and was scheduled to return that July. But when an unmanned SpaceX Falcon 9 exploded after liftoff, the return was pushed back to May 2016.

"It just blows my mind that humans are able to do this," Rasmussen said of having her experiment launched into space. "It's pretty cool."

Lenore Rasmussen working in a PPPL laboratory.

Stacia Zelick

STACIA ZELICK, NEW CHIEF INFORMATION OFFICER

Stacia Zelick, PPPL's new chief information officer, brings years of experience in information technology to the job. She also brings a disco ball that a friend gave her when she was on her first job and that has followed her ever since. She installs it and plays music in her office. "Every once in a while you just have to unwind by singing and dancing it out," Zelick said. "I love what I do and I do what I love. My management style is very open."

Zelick holds a bachelor's degree in computer information systems from a joint program at Rutgers University and the New Jersey Institute of Technology; an MBA in management information systems from Montclair State University; and a PhD in organization and management from Capella University in Minnesota.

She previously was director of Information Technology at Rutgers University-Newark, where she managed a budget of more than $4 million and a staff of 26 full-time employees and 100 student employees. Prior to that her positions have included IT manager at Kent State University in Ohio, and director of Technical Support Services at Montclair State University.

Larry Bernard

LARRY BERNARD, NEW DIRECTOR OF COMMUNICATIONS

Larry Bernard, PPPL's new director of communications, is a proven developer of highly successful internal and external communications programs. His positions have included senior communications manager at Amgen, a major biopharmaceutical company; senior manager for worldwide R&D and medical communications at pharmaceutical giant Pfizer Inc.; and senior communications director at a national health care policy think tank.

Bernard holds bachelor's and master's degrees from Northwestern University's Medill School of Journalism and has held a number of journalistic positions.

He leads the PPPL communications team and is creating and implementing a plan to increase the visibility of the Laboratory's leadership role in research on magnetic fusion energy and the science of plasma physics. "It's truly an honor to work at such an illustrious laboratory with such distinguished scientists and staff," he says. "It's an exciting opportunity, and a privilege, to be a part of something so special – creating the means for virtually limitless energy for all mankind."

Laurie Bagley

LAURIE BAGLEY, NEW HEAD OF TECHNOLOGY TRANSFER

Laurie Bagley, the new head of Technology Transfer at PPPL, brings her enthusiasm for PPPL's numerous inventions and an impressive background in science and technology to the position.

Bagley holds a bachelor's degree in chemistry from Millersville University in Pennsylvania and was previously a technology licensing assistant at Princeton University. She founded her own consulting firm, which worked on licensing and patents for companies that included Bristol-Myers Squibb and Johnson & Johnson. Prior to that, she was a research chemist at J&J in New Brunswick, where she led the team that developed a vinyl formulation for Band-Aid® bandages.

She is passionate about bringing PPPL's numerous inventions to the public and finding new inventors among the engineers and scientists at PPPL. She encourages the Laboratory's researchers to come forward with ideas and inventions that could be licensed and patented and turned into commercial products. "I love learning new things every day," she said, "and that's exactly what this job is, finding out exactly what's going on and trying to market it."

FUSION ENERGY IS THE SUPER POWER IN NEW COMIC BOOK

PPPL has produced a glossy new comic book that describes the prospect and power of fusion energy. Titled "A Star for Us," the 12-page comic uses dramatic and eye-catching images and clear writing to tell the story of the quest for fusion and the efforts at PPPL and around the world to create it. Artist Frank Espinosa produced the images and Sajan Saini, a lecturer in the Princeton University Writing Program, wrote the text. "I thought this was a terrific opportunity to really capture in evocative visuals a leading-edge national research program for this country," Saini said.

SCIENCE ON SATURDAY

Lecture-goers of all ages flock to the weekly Science on Saturday presentations that PPPL has hosted during the winter since 1984. Here physicist Alan Hirschfield of the University of Massachusetts-Dartmouth discusses the "star detective" inventors who developed the devices that made modern astronomy possible.

YOUNG WOMEN FIND FUN AND INSPIRATION AT ANNUAL PPPL-SPONSORED CONFERENCE

More than 450 7th to 10th grade girls from schools throughout New Jersey and from Pennsylvania and Maryland attended the 2015 Young Women's Conference. The yearly event, sponsored by PPPL on the main campus of Princeton University, aims to ignite interest in science, technology engineering and math (STEM), fields in which women are underrepresented.

Attendees tried hands-on experiments at 25 exhibits, toured laboratories and heard panel discussions about women in science. The day culminated with a keynote speech by astrophysicist Kerstin Perez of Haverford College, who studies dark matter. Following her talk, a student asked if Perez ever doubted herself since she was surrounded by so many men in her job. "I never consciously thought, 'I'm a woman I can't do this,'" Perez said. "But I did struggle with doubt. One piece of advice is to believe people when they compliment you. When people give you an A, it's because you did a good job."

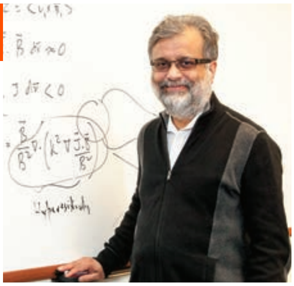
A Rutgers graduate student shows how water splits into hydrogen and oxygen during the conference.

HIGH SCHOOL AND COLLEGE INTERNSHIPS

The Science Education department at PPPL runs internships for high school and college students throughout the year. A nine-week summer program for college students from across the country begins with a week-long course in plasma physics; students spend the rest of the summer working on projects with staffers at PPPL or other national laboratories. Fall and spring internships begin without the week-long course.

High school internships are 16-week, school-year programs for outstanding students from New Jersey who spend the term working on projects at PPPL. Shown here from left are spring semester interns Desirée Koontz, Willma Arias de la Rosa and Xaymara Rivera from North Star Academy in Newark.

AMITAVA BHATTACHARJEE ELECTED A FELLOW OF THE AMERICAN GEOPHYSICAL UNION


Amitava Bhattacharjee

Amitava Bhattacharjee, head of PPPL's Theory Department and professor of astrophysical sciences at Princeton University, has been elected a fellow of the American Geophysical Union (AGU). The award, bestowed on less than one-tenth of one percent of AGU members each year, is given to those who have "made exceptional contributions to Earth and space sciences as valued by their peers." Bhattacharjee was recognized for "seminal contributions to our understanding of reconnection processes and turbulence in the solar corona, interplanetary medium, and planetary magnetospheres."

"I feel deeply honored to have been named an AGU Fellow," said Bhattacharjee, who is one of only three honorees from the entire space physics and aeronomy — or upper atmosphere — section of the union in 2015. "Being recognized by one's peers is deeply gratifying."

LUIS DELGADO-APARICIO WINS DOE EARLY CAREER GRANT


Luis Delgado-Aparicio

Physicist Luis Delgado-Aparicio of PPPL won an Early Career Research Program award sponsored by the DOE's Office of Science. The five-year, $2.6 million grant will fund Delgado-Aparicio's research aimed at eliminating a key barrier to developing fusion energy as a safe, clean, and abundant source of generating electricity.

Delgado-Aparicio's research focuses on impurities – tiny particles that can cool the plasma and slow or halt the fusion reaction. He is developing a process that would enable researchers to pinpoint and analyze the impurities and quickly flush them out of the plasma.

The award marks the third Early Career grant in as many years for researchers at PPPL. Physicists Brian Grierson won the award in 2014 and Ahmed Diallo received the award in 2013.

CHRISTOPHER BRUNKHORST HONORED WITH INVENTORS AWARD

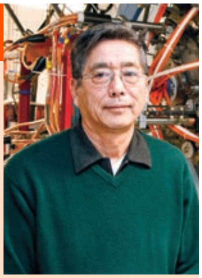

Christopher Brunkhorst

The New Jersey Inventors Hall of Fame honored engineer Chris Brunkhorst with a 2015 Inventors Award for developing "a novel technique to significantly reduce Salmonella poisoning by pasteurizing eggs with radio frequency heating."

The invention uses RF energy to transmit heat through the shell to directly heat the yolk while the egg rotates. Cool water simultaneously flows over the egg to protect the delicate white; researchers then bathe the egg in hot water to complete the pasteurization.

Brunkhorst developed the technique, which has been patented, with engineers at the USDA Agricultural Research Service in Wyndmoor, Pennysylvania.

PHYSICIST MASAAKI YAMADA WINS THE 2015 JAMES CLERK MAXWELL PRIZE IN PLASMA PHYSICS


Masaaki Yamada

Masaaki Yamada, a Distinguished Laboratory Research Fellow at PPPL, has won the 2015 James Clerk Maxwell Prize in Plasma Physics. The award from the American Physical Society (APS) Division of Plasma Physics recognized Yamada for "fundamental experimental studies of magnetic reconnection relevant to space, astrophysical and fusion plasmas, and for pioneering contributions to the field of laboratory plasma astrophysics."

"I am honored and pleased to be recognized," said Yamada, the principal investigator for PPPL's Magnetic Reconnection Experiment (MRX), the world's leading laboratory facility for studying reconnection—an astrophysical process that produces solar flares, the northern lights, and geomagnetic storms.

"Masaaki's work has reshaped our understanding of magnetic reconnection," said PPPL Director Stewart Prager. "The results have impacted both space physics and fusion plasma physics."


Chuck Kessel

CHUCK KESSEL WINS THE 2015 FUSION TECHNOLOGY AWARD

Chuck Kessel, a principal engineer at PPPL, has won the 2015 Fusion Technology Award. The honor from the Institute of Electrical and Electronics Engineers' (IEEE) Nuclear and Plasma Sciences Society recognizes outstanding contributions to fusion engineering and technology.

"Chuck has long been a widely recognized pioneer in developing advanced tokamak operating scenarios that have served as the basis for several machine design concepts," said Michael Williams, former associate director for engineering and infrastructure at PPPL and a past recipient of the honor. "Receiving the 2015 Fusion Technology Award duly recognizes Chuck's outstanding contributions to the development of fusion technology." His comprehensive approach is widely appreciated. "Kessel's work has always been at the intersection of plasma research and technology," said Richard Hawryluk, head of PPPL's ITER and Tokamaks Department.

PPPL RECOGNIZED FOR GREEN ELECTRONICS PURCHASES

The Green Electronics Council, a nonprofit that promotes the environmentally friendly use of electronic technologies, recognized PPPL's efforts to purchase greener electronics with a national award. The Laboratory received a three-star "EPEAT Purchaser Award," the organization's highest honor, during a 2015 Earth Day ceremony at the U.S. Department of Energy's headquarters in Washington D.C. The award recognizes organizations purchasing electronics that use less energy and can be donated or recycled when they outlive their usefulness. Some 82 percent of PPPL's electronic purchases in fiscal year 2014 met EPEAT's standards for green electronics.


Kyron Jones, excess property coordinator, operating a forklift to lift used electronic devices following an electronics collection on Earth Day.

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